

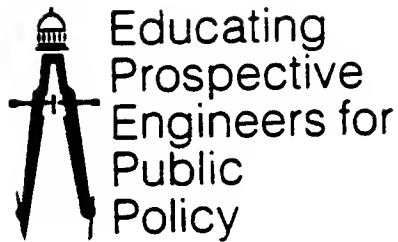
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NUCLEAR FUEL CYCLE REPROCESSING POLICY
THE BARNWELL NUCLEAR FUEL PLANT EXPERIENCE

PATRICIA L. CAMPBELL

A study of the technical and policy developments concerning the reprocessing of spent reactor fuel from nuclear power reactors.

A Case Under the WISE Program



NUCLEAR FUEL CYCLE REPROCESSING POLICY
THE BARNWELL NUCLEAR FUEL PLANT EXPERIENCE

by

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Part A: THE NUCLEAR FUEL CYCLE

The nuclear fuel cycle is the step-by-step utilization of uranium from exploration and mining to final disposal of high-level wastes or spent fuel from the production of electricity in commercial nuclear power plants (see Exhibit A-1). Reprocessing allows for recovery of valuable resources, namely uranium and plutonium, and reduces the amount of high-level radioactive waste that requires disposal. The recovered uranium can be recycled as fuel for reactors, or a mixture of uranium and plutonium, referred to as mixed-oxide fuel, can be used if approved by the licensing agency, Nuclear Regulatory Commission. Reprocessing is essential for providing plutonium for fueling the breeder reactor.

Each ton of spent fuel contains uranium and plutonium with energy equivalent of almost 200,000 barrels of oil. Reprocessing reduces the amount of uranium mining and enrichment by 33% and 25% respectively. In addition to reducing the volume of high-level radioactive wastes, the period of time required for the waste to reach a hazard value equivalent to that of original ore is 500 years for reprocessed wastes compared to 10,000 years for spent fuel, and the final form of the waste is much more chemically stable. The high level wastes can be combined with molten glass formers and vitrified, the method currently used in France for waste management.

The chemical process that separates uranium, plutonium, and fission by-products is a solvent extraction process based on the fact that plutonium's chemical properties vary with its oxidation state. Spent fuel is dissolved in nitric acid. This liquid is then mixed with an organic solvent. Uranium and plutonium ions migrate into the solvent while fission products do not. After several purgings, the fission products are removed and the plutonium is separated from the uranium stream by an oxidation process that causes it to precipitate in the form of plutonium nitrate.

All nuclear plants to-date were designed with reprocessing in mind so that only a limited amount of storage area for spent fuel was provided. If reprocessing of commercial spent fuel does not become available in this century, utilities or government spent fuel storage areas must be built for that now accumulating.

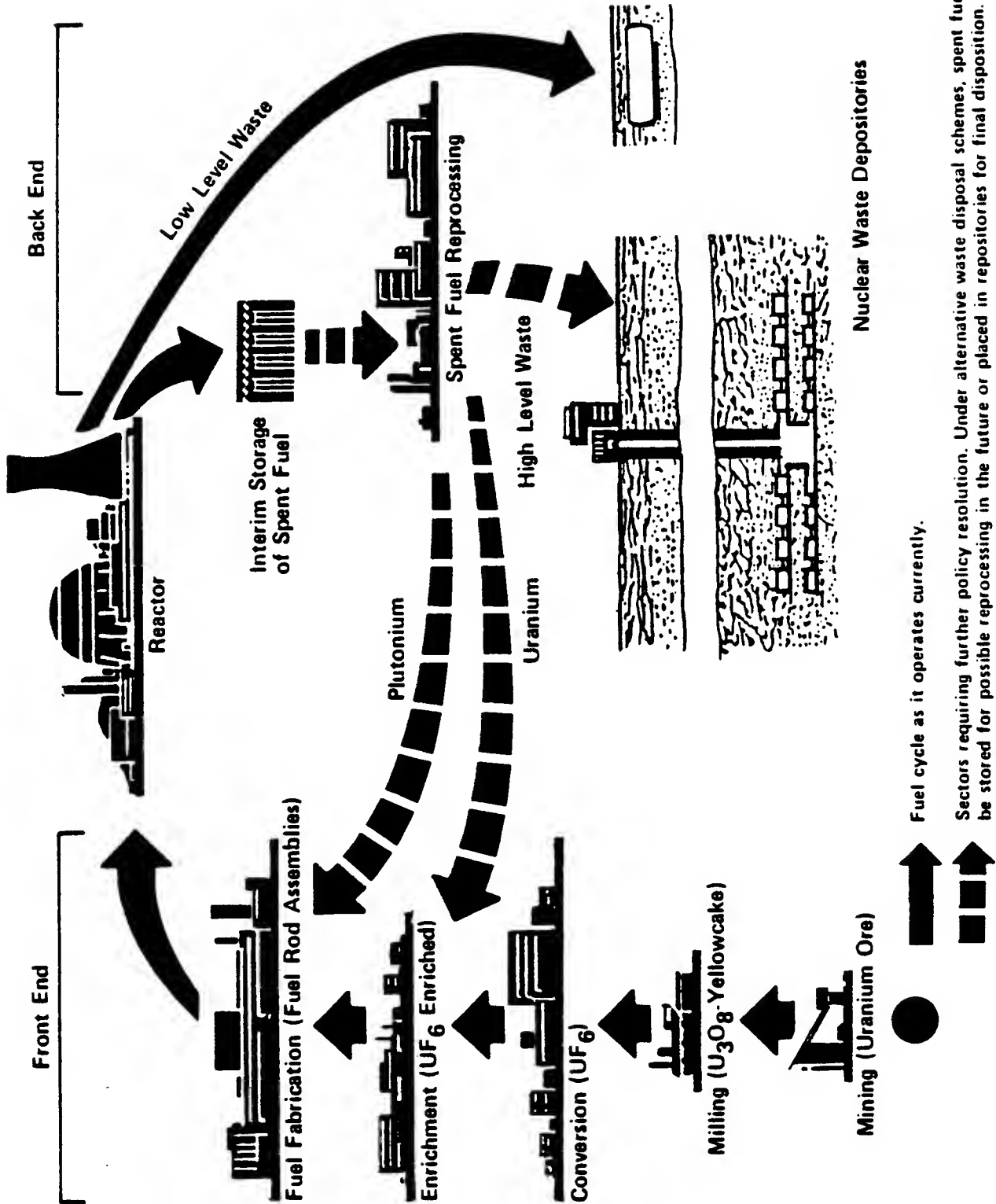


Exhibit A-1

Part B: FROM GOVERNMENT TO PRIVATE INDUSTRY

The Atomic Energy Commission (AEC) was created in 1946 and the responsibility for atom splitting was transferred from the Army Corps of Engineers' Manhattan Project to this new five-member civilian commission which was directed to encourage the development of peaceful uses of atomic energy. During the Eisenhower Administration, the Atomic Energy Act of 1954 was passed, allowing private industry to develop nuclear power plants with the government retaining control of the nuclear fuel. In 1953, Congress had appropriated funding for a demonstration project and by 1957 the Westinghouse reactor was in operation at Shippingport, Pennsylvania. A new industry was born.

In 1964, Congress authorized the sale to private industry of uranium enriched at government facilities. While the government remained responsible for disposing of the wastes left after the fuel was used, the AEC encouraged private industry development of plants to reprocess spent fuel from power reactors.

In the late 1960's and early 1970's, two private companies, Nuclear Fuel Services (NFS) and General Electric (GE), made attempts to provide small-scale (300 metric tons per year) reprocessing services. The NFS plant operated for a short time, but government-required modifications resulted in commercial failure of the venture. The GE plant never operated, as tests indicated that a change to the basic process would not work as designed and modifications did not appear to be economically feasible.

In 1968, Allied Chemical filed an application for a large-scale (1500 metric tons per year) reprocessing plant. The government helped arrange for land purchase next to the Savannah River Plant, a military reprocessing plant near Barnwell, South Carolina. After Gulf Oil became a partner, Allied-General Nuclear Services (AGNS) was created. The Barnwell Nuclear Fuel Plant (BNFP) was to utilize the basic government process with tributyl phosphate as the solvent, referred to as the "Purex" process.

In 1976, Dr. James Buckham joined AGNS as Executive Vice President, later becoming President. He received his PhD in chemical engineering in 1953 and had been researching and developing processes involving nuclear fuel for a number of years at the government's Idaho Chemical Processing Plant. He was awarded the Robert E. Wilson Award by the American Institute of Chemical Engineers in 1974 for his outstanding accomplishments. He came to AGNS with the expectation that BNFP would be licensed and operating in a few years. At this time, the major facilities of the plant were complete: fuel receiving and storage station, separations facility, uranium hexafluoride facility, and liquid waste storage tanks.

As Executive Vice President, Dr. Buckham was responsible for all the operational and technical aspects of the plant. Later, as President, he was also responsible for the administrative portion. At this time, reprocessing appeared to be a profitable enterprise if managed well, based on the expected sale of uranium and plutonium. The Nuclear Regulatory Commission had not completed licensing for mixed-oxide fuel, but they were proceeding towards this. There was a need for plutonium for the Clinch River Breeder Reactor being developed by the government, and Westinghouse was considering building a fuel fabrication plant for mixed-oxide fuel. Dr. Buckham felt good about the progress of industry.

Part C: THE CARTER ADMINISTRATION

Presidential Statement

On April 7, 1977 President Jimmy Carter, citing the nuclear nonproliferation policy of his administration, indefinitely deferred commercial reprocessing (see Exhibit C-1). In his statement, Carter spoke of BNFP:

The plant at Barnwell, South Carolina...will receive neither Federal encouragement nor funding from us for its completion as a reprocessing facility.

Department of Energy Contract

In spite of this, Congress required the Department of Energy (DOE) to fund research and development of methods to prevent diversion of plutonium at the Barnwell plant. The Subcommittee on Energy Research and Production under the House of Representatives Committee on Science and Technology was in support of BNFP as well as several members of Congress. This subcommittee was instrumental in obtaining funding for the research project.

NUCLEAR POWER POLICY

The President's Remarks Announcing His Decisions Following a Review of U.S. Policy and a Question-and-Answer Session With Reporters. April 7, 1977

THE PRESIDENT. Good morning, everybody.

I have two items to discuss with you this morning. Then I'd like to answer a few questions.

ECONOMIC STIMULUS PACKAGE

One relates to the economy and the need for continuing emphasis on the stimulation package. Based on the best information available to us now, we'll have an accumulated spending shortfall for this current fiscal year, fiscal year 1977, plus revenue collections in excess of the anticipated amount, of about \$10 billion. In other words, we have collected about \$10 billion more from the American taxpayers than we anticipate spending in 1977.¹

I feel very strongly that this money should go back to the American taxpayers. We need it for the economy to maintain its present strength. And the only equitable way that I see is through the already prepared tax refund which would average about \$50 per person which, as I have said before, would be about 30 percent of the 1976 income taxes paid by a family making about \$10,000 a year.

NUCLEAR POWER POLICY

The second point I'd like to make before I answer questions is concerning our Nation's efforts to control the spread of nuclear explosive capability. As far back as 30 years ago, our Government made a proposal to the United Nations that there be tight international controls over nuclear fuels and particularly those that might be made into explosives.

Last year during the Presidential campaign, both I and President Ford called for strict controls over fuels to prevent the proliferation—further proliferation of nuclear explosive capability.

There is no dilemma today more difficult to address than that connected with the use of atomic power. Many countries see atomic power as their only real opportunity to deal with the dwindling supplies of oil, the increasing price of oil, and the ultimate exhaustion of both oil and natural gas.

Our country is in a little better position. We have oil supplies of our own, and we have very large reserves of coal. But even coal has its limitations. So, we will ourselves continue to use atomic power as a share of our total energy production.

The benefits of nuclear power, particularly to some foreign countries that don't have oil and coal of their own, are very practical and critical. But a serious risk is involved in the handling of nuclear fuels—the

¹ Later in the day, the White House Press Office issued the following clarification of the President's statement: "The Federal deficit is expected to be \$10 billion less than anticipated this year, because we are collecting more in taxes, and spending less than we anticipated."

risk that component parts of this power process will be turned to providing explosives or atomic weapons.

We took an important step in reducing this risk a number of years ago by the implementation of the nonproliferation treaty which has now been signed by approximately a hundred nations. But we must go further.

We have seen recently India evolve an explosive device derived from a peaceful nuclear powerplant, and we now feel that several other nations are on the verge of becoming nuclear explosive powers.

The United States is deeply concerned about the consequences of the uncontrolled spread of this nuclear weapon capability. We can't arrest it immediately and unilaterally. We have no authority over other countries. But we believe that these risks would be vastly increased by the further spread of reprocessing capabilities of the spent nuclear fuel from which explosives can be derived.

Plutonium is especially poisonous, and, of course, enriched uranium, thorium and other chemicals or metals can be used as well.

We are now completing an extremely thorough review of our own nuclear power program. We have concluded that serious consequences can be derived from our own laxity in the handling of these materials and the spread of their use by other countries. And we believe that there is strong scientific and economic evidence that a time for a change has come.

Therefore, we will make a major change in the United States domestic nuclear energy policies and programs which I am announcing today.

We will make a concerted effort among all other countries to find better answers to the problems and risks of nuclear proliferation. And I would like to outline a few things now that we will do specifically.

First of all, we will defer indefinitely the commercial reprocessing and recycling of the plutonium produced in U.S. nuclear power programs.

From my own experience, we have concluded that a viable and adequate economic nuclear program can be maintained without such reprocessing and recycling of plutonium. The plant at Barnwell, South Carolina, for instance, will receive neither Federal encouragement nor funding from us for its completion as a reprocessing facility.

Second, we will restructure our own U.S. breeder program to give greater priority to alternative designs of the breeder other than plutonium, and to defer the date when breeder reactors would be put into commercial use.

We will continue research and development, try to shift away from plutonium, defer dependence on the breeder reactor for commercial use.

Third, we will direct funding of U.S. nuclear research and development programs to accelerate our research into alternative nuclear fuel cycles which do not involve direct access to materials that can be used for nuclear weapons.

Fourth, we will increase the U.S. capacity to produce nuclear fuels, enriched uranium in particular, to provide adequate and timely supplies of nuclear fuels to countries that need them so that they will not be required or encouraged to reprocess their own materials.

Fifth, we will propose to the Congress the necessary legislative steps to permit us to sign these supply contracts and remove the pressure for the reprocessing of nuclear fuels by other countries that do not now have this capability.

Sixth, we will continue to enlarge the export of either equipment or technology that could permit uranium enrichment and chemical reprocessing.

And seventh, we will continue discussions with supplying countries and recipient countries, as well, of a wide range of international approaches and frameworks that will permit all countries to achieve their own energy needs while at the same time reducing the spread of the capability for nuclear explosive development.

Among other things—and we have discussed this with 15 or 20 national leaders already—we will explore the establishment of an international nuclear fuel cycle evaluation program so that we can share with countries that have to reprocess nuclear fuel the responsibility for curtailing the ability for the development of explosives.

One other point that ought to be made in the international negotiation field is that we have to help provide some means for the storage of spent nuclear fuel materials which are highly explosive, highly radioactive in nature.

I have been working very closely with and personally with some of the foreign leaders who are quite deeply involved in the decisions that we make. We are not trying to impose our will on those nations like Japan and France and Britain and Germany which already have reprocessing plants in operation. They have a special need that we don't have in that their supplies of petroleum products are not available.

But we hope that they will join with us—and I believe that they will—in trying to have some worldwide understanding of the extreme threat of the further proliferation of nuclear explosive capability. I'd be glad to answer a few questions.

QUESTIONS

Q. Mr. President, in the last administration there was some proposal to have regional reprocessing centers which, in some people, to put the emphasis on the wrong thing. Does this mean that you are going to not favor regional reprocessing centers? And, secondly, would you be prepared to cut off supplies of any kind of nuclear material to countries that go nuclear?

THE PRESIDENT. Well, I can't answer either one of those questions yet. I have had detailed discussions with Prime Minister Fukuda, with Chancellor Schmidt, and also with Prime Minister Callaghan, for instance, just in recent days about a joint approach to these kinds of problems.

Obviously, the smaller nations, the ones that now have established atomic powerplants, have to have someplace either to store their spent fuel or to have it reprocessed. And I think that we would very likely see a continuation of reprocessing capabilities within those nations that I have named and perhaps others.

We in our own country don't have this requirement. It's an option that we might have to explore many, many years in the future.

But I hope that by this unilateral action we can set a standard and that those countries that don't now have reprocessing capability will not acquire that capability in the future. Regional plants under tight international control obviously is one option that we would explore. No decision has been made about that.

If we felt that the provision of atomic fuel was being delivered to a nation that did not share with us our commitment to nonproliferation, we would not supply that fuel.

Q. Mr. President, this carries an assurance, which you had said earlier, for an assured and adequate supply of enriched uranium to replace the need for plutonium. Do you foresee any kind of price guarantees also for underdeveloped and poorer countries so that the supply would not only be assured but at a reasonable price in case lack of reprocessing drove prices up?

THE PRESIDENT. I don't know what the future prices of uranium might be. At the present time, of the enriched uranium that we produce, about roughly a third of it is reprocessed, roughly a third of it is used for our domestic needs, and about a third of it is put in storage.

There has been an accumulation in recent years of the projected atomic powerplant construction in our own

country. Other nations, though, are moving more and more toward atomic powerplants. But I can't tell you at this point that we will guarantee a price for uranium fuel that's less than our own cost of production, and that would be a matter of negotiation, perhaps even on an individual national basis.

I think that a standard price would probably be preferable, but then we might very well give a particular nation that was destitute or a very close friend of ours or who cooperated with us in this matter some sort of financial aid to help them with the purchase.

Q. You also said last year a couple of times that you hoped to call a world energy conference to discuss this as well as a lot of other things. Do you foresee that happening any time in the near future?

THE PRESIDENT. The item of nuclear powerplants and the handling of spent nuclear fuels and the curtailment of the possibility of new nations joining us in their capability for explosives will be on the agenda in the discussions in London early in May. And this will be a continuing process for us.

I might add that Secretary Vance also discussed this question with the Soviet authorities on his recent visit to Moscow and asked them to join in with us in enhancing the nonproliferation concept. Their response was favorable. But it will entail a great deal of negotiation, and I can't anticipate what the results of those negotiations might be. We obviously hope for it to apply to all the nations to the world.

Q. Mr. President, does your change in the domestic program mean that you will not authorize building the Clinch River breeder reactor in Tennessee?

THE PRESIDENT. The Clinch River breeder reactor will not be terminated as such. In my own budget recommendations to the Congress, we cut back—I can't remember the exact figure—about \$250 million out of the plutonium breeder reactor—the liquid metal fast breeder reactor program.

I think that we would continue with the breeder reactor program on an experimental basis, research and development, but not move nearly so rapidly toward any sort of commercial use.

We also, obviously, are concerned about the adverse economic impact of these changes. And in the areas that would lose employment that was presently extant, as we increase our capacity for producing nuclear fuels, even using new techniques, other than gaseous diffusion, like centrifuge and laser beam use, then we would try to locate those facilities over a period of time. It's a very slow-moving process—in areas like Clinch River where they might be adversely affected.

Q. Mr. President, does this mean that Canada selling nuclear power equipment to France and others, and France selling to others, does this mean that we will supply those other countries so that they won't make unre-power?

THE PRESIDENT. Well, I might say that the two countries that most nearly share our commitment and even moved ahead of us in this field have been Canada—perhaps because of their unfortunate experience with India and Australia. Both these countries, along with us, have substantial supplies of nuclear fuel themselves.

I would hope that we could develop an interrelationship with other countries to remove the competitive aspect of reprocessing itself. There is obviously going to be continued competition among our own Nation, Canada, France, Germany, England, in the selling of atomic powerplants themselves. It ought to be a clearly drawn distinction between the legitimate and necessary use of uranium and other enriched fuels to produce electricity, on the one hand, and a prohibition against the use of those fuels for explosives.

It would be impossible, counterproductive, and ill-advised for us to try to prevent other countries that need it from having the capability to produce electricity from atomic power. But I would hope that we and the other countries could form an alliance that might be fairly uniform in this respect. I know that all the other countries share with us this hope.

The one difference that has been very sensitive, as it relates to, say, Germany, Japan, and others, is that they fear that our unilateral action in renouncing the reprocessing of spent fuels to produce plutonium might imply that we prohibit them or criticize them severely because of their own need for reprocessing. This is not the case. They have a perfect right to go ahead and continue with their own reprocessing efforts. But we hope they'll join with us in eliminating in the future additional countries that might have had this capability evolve.

Q. Mr. President, is it your assessment, sir, that some of the smaller nations that are now seeking reprocessing technology are doing so in order to attain nuclear weapon capability as well as or in addition to meeting their legitimate energy needs?

THE PRESIDENT. Well, without going into specifics—I wouldn't want to start naming names—I think it's obvious that some of the countries about whom we are concerned have used their domestic nuclear powerplants to develop explosive capability. There is no doubt about it.

India, which is historically a peaceful nation, at least as far as worldwide connotations are concerned, did evolve an explosive capability from supplies that were given to them by the Canadians and by us.

And we feel that there are other nations that have potential capacity already for the evolution of explosives. But we are trying to make sure that from this point on that the increasing number of nations that might have joined the nuclear nations is attenuated drastically.

We can't undo immediately the mistakes that have been made in the past. But I believe that this is a step in the right direction.

Nuclear Power Policy

Statement by the President on His Decisions Following a Review of U.S. Policy. April 7, 1977

Just one more question. Q. Mr. President, are you willing to trade off your scrapping of 30 water projects or even some of them in exchange for a tax rebate package?

THE PRESIDENT. Well, I am not much of a trader. That is one of my political defects for which I have been criticized a great deal. We will be receiving the report on the analysis of water projects about April 15. I am not sure if that exact date will be met. And I'll assess each one of those projects on its own merits. And I would hope that the \$50 tax refund will also be assessed on its own merits.

I know enough about politics to realize that we will lose some votes perhaps within the Congress because of water projects that we don't advocate. I also realize that there might be water projects that would be completed, I think ill-advisedly, against my inclinations. I don't have the final say-so about it. So there will have to be some interrelationship there. I wish and hope there is little, if any. But I can't prevent that.

But I am not inclined at all to trade a water project that's not needed or my approval of it in return for a vote on the tax refund which I think is needed for every Member of Congress and the people that look to that Congress Member for leadership.

Q. What's your forecast on the passage of the tax rebate?

THE PRESIDENT. I don't know yet. Majority Leader Byrd and Senator Cranston, Senator Humphrey, and others had a meeting I believe on Tuesday. They had additional meetings yesterday.

They are working very hard on this vote. I talked to Senator Byrd this morning, and he gave me a report on the progress that he thought we were making. And also the Vice President and I are contacting some of the Members of the Senate to let them know about our arguments on why the tax refund should be given back to the American people.

This morning I drafted about a 1½ page summary of the arguments in favor of the tax refund to the American people, including the shortfall in spending and the over-collection of taxes which is a recent development. I think that prospects still look good.

Thank you very much.

REPORTER. Thank you, Mr. President.

There is no dilemma today more difficult to resolve than that connected with the use of nuclear power. Many countries see nuclear power as the only real opportunity, at least in this century, to reduce the dependence of their economic well-being on foreign oil—an energy source of uncertain availability, growing price, and ultimate exhaustion. The U.S., by contrast, has a major domestic energy source—coal—but its use is not without penalties, and our plans also call for the use of nuclear power as a share in our energy production.

The benefits of nuclear power are thus very real and practical. But a serious risk accompanies worldwide use of nuclear power—the risk that components of the nuclear power process will be turned to providing atomic weapons.

will go to families earning less than \$15,000 and another 25% to those between \$15,000-\$20,000. A working family of four will get \$200. The program also covers senior citizens and working families who have no tax liability. For a family of four earning \$10,000 this will mean a 30% reduction in their tax liability. Combined with our proposal to increase the standard deduction, their tax liability would be reduced by 50%.

2. The economy will need fiscal stimulus to maintain strong growth rate and keep unemployment moving down steadily over the rest of this year. In economic activity partly reflects natural recovery from the depressing effects of the cold weather and business rebuilding inventories. These influences on the recovery will be temporary.

(b) To date the Federal Government has prospectively spent less and collected more than we anticipated, to the tune of about \$10 billion. This will certainly slow down the recovery unless we do something about it. The \$11 billion tax rebate is the only way we can offset this economic drag now. It is the only fair way to do so for the American taxpayer.

3. Continued growth and reduction in unemployment depends on strong consumer spending. In the absence of the rebate, consumer spending could weaken in 1977. Added fuel bills and rising food prices will siphon off some consumer purchasing power.

4. The rebate will work. It is a tested method for stimulating consumer spending.

(a) About 60% of the 1975 rebate was spent. The proportion could be higher in 1977 because consumer confidence is stronger now.

(b) The rebate will affect the economy quickly. The jobs and public works programs we have recommended will take some time to get underway.

5. The rebate means 250,000 more jobs and \$15 billion in added GNP by the end of the year. Without the rebate, we will lose these jobs and the added income.

6. The rebate preserves options for the future.

(a) For permanent tax reform.

(b) For expansion of other needed programs.

(c) For balanced budget by fiscal year 1981.

7. With present levels of high unemployment and idle capacity, rebate should not add significantly to inflationary pressures.

8. Without the rebate, too large a proportion of the tax reduction would be going to businesses and not enough to consumers.

We took an important step in reducing the risk of expanding possession of atomic weapons through the Non-Proliferation Treaty, whereby more than 100 nations have agreed not to develop such explosives. But we must go further. The U.S. is deeply concerned about the consequences for all nations of a further spread of nuclear weapons or explosive capabilities. We believe that these risks would be vastly increased by the further spread of sensitive technologies which entail direct access to plutonium, highly enriched uranium, or other weapons usable material. The question I have had under review from my first day in office is how can that be accomplished without forgoing the tangible benefits of nuclear power.

We are now completing an extremely thorough review of all the issues that bear on the use of nuclear power. We have concluded that the serious consequences of proliferation and direct implications for peace and security—as well as strong scientific and economic evidence—require a major change in U.S. domestic nuclear energy policies and programs; and — a concerted effort among all nations to find better answers to the problems and risks accompanying the increased use of nuclear power.

I am announcing today some of my decisions resulting from that review.

First, we will defer indefinitely the commercial reprocessing and recycling of the plutonium produced in the U.S. nuclear power programs. From our own experience, we have concluded that a viable and economic nuclear power program can be sustained without such reprocessing and recycling. The plant at Barnwell, South Carolina, will receive neither Federal encouragement nor funding for its completion as a reprocessing facility.

Second, we will restructure the U.S. breeder reactor program to give greater priority to alternative designs of the breeder and to defer the date when breeder reactors would be put into commercial use.

Third, we will redirect funding of U.S. nuclear research and development programs to accelerate our research into alternative nuclear fuel cycles which do not involve direct access to materials usable in nuclear weapons.

Fourth, we will increase U.S. production capacity for enriched uranium to provide adequate and timely supply of nuclear fuels for domestic and foreign needs.

Fifth, we will propose the necessary legislative steps to permit the U.S. to offer nuclear fuel supply contracts and guarantee delivery of such nuclear fuel to other countries.

Sixth, we will continue to embargo the export of equipment or technology that would permit uranium enrichment and chemical reprocessing.

Seventh, we will continue discussions with supplying and recipient countries alike, of a wide range of international approaches and frameworks that will permit all nations to achieve their energy objectives while reducing the spread of nuclear explosive capability. Among other

Part D: THE DOE CONTRACT

After Carter's decision was announced, AGNS held a board meeting. Dr. Buckham remembers that they considered two possible options: 1) close the plant immediately, 2) wait and see if the policy holds. Option 2 was based on the encouragement AGNS was receiving from members of Congress who felt that reprocessing was still desirable in the United States. AGNS chose to wait. Dr. Buckham says that he thought a reversal in Carter's policy would occur within four to six months.

Along with the ban on reprocessing, the Nuclear Regulatory Commission stopped the studies for Generic Environmental Statement on Mixed-Oxide Fuel (GESMO) and Westinghouse announced they would not proceed with the mixed-oxide fuel fabrication plant. These events had a major affect on AGNS and the waiting game because this made reprocessing a much less attractive business venture. Under these circumstances, only the uranium would have a market; plutonium would not.

AGNS entered into the DOE contract not knowing exactly what the expected results were. Dr. Buckham met with officials of the DOE several times to discuss the terms of the contract and outline a program. One of the major reasons AGNS wanted the contract was to keep the staff at the plant, but not to the extent of one recommendation made to Dr. Buckham: let everyone go on vacation. He wanted actual research projects for his employees. The result of the meetings was a decision to develop the "most sophisticated nuclear safeguards system in the world."

The Advanced Integrated Safeguards System was designed to account for special nuclear material using instruments interconnected through a number of minicomputers to a physical protection system including voice verification, video observation, motion and intrusion detectors, access controls and verification, and alarms. Dr. Buckham is very proud of the system and feels that it has been tested and verified to be acceptable. Along with safeguards, proliferation-resistant fuel processes were studied. Other areas covered in the DOE contract included spent fuel storage, handling, and transportation. The biggest problem Dr. Buckham had involving the contract was to write programs each year for funding approval that could begin and reach an end in the year of funding. He always felt that each year would be the last year government funding would be required. One example of this comes from the 1980 testimony before the Subcommittee on Energy Research and Production:

...the owners of the BNFP are reluctant to seek continued R&D funding beyond FY 1981. Our hope is that Barnwell be transferred to the government on an equitable basis during FY 1981. Actions can be initiated by Congress, now, which will lead to the transfer of the Barnwell facility to the government during FY 1981.

Part E: THE REAGAN ADMINISTRATION

The government did not take possession of BNFP in 1981 as AGNS hoped. Ronald Reagan was inaugurated President that year and his Administration brought many changes in policy.

The Reagan Administration can be characterized by a general attitude of encouragement for private industry with as little government interference or involvement as possible. This was evidenced by his nuclear policy statement issued October 8, 1981, which lifted the ban on reprocessing with the charge that the private sector take the lead while the government pursue stable long-term policies and eliminate regulatory impediments (see Exhibit E-1).

Nuclear Energy Policy

Statement Announcing a Series of Policy Initiatives. October 8, 1981

A more abundant, affordable, and secure energy future for all Americans is a critical element of this administration's economic recovery program. While homeowners and business firms have shown remarkable ingenuity and resourcefulness in meeting their energy needs at lower cost through conservation, it is evident that sustained economic growth over the decades ahead will require additional energy supplies. This is particularly true of electricity, which will supply an increasing share of our energy.

If we are to meet this need for new energy supplies, we must move rapidly to eliminate unnecessary government barriers to efficient utilization of our abundant, economical resources of coal and uranium. It is equally vital that the utilities—investor-owned, public, and co-ops—be able to develop new generating capacity that will permit them to supply their customers at the lowest cost, be it coal, nuclear, hydro, or new technologies such as fuel cells.

One of the best potential sources of new electrical energy supplies in the coming decades is nuclear power. The U.S. has developed a strong technological base in the production of electricity from nuclear energy. Unfortunately, the Federal Government has created a regulatory environment that is forcing many utilities to rule out nuclear power as a source of new generating capacity, even when their consumers may face unnecessarily high electric rates as a result. Nuclear power has become entan-

gled in a morass of regulations that do not enhance safety but that do cause extensive licensing delays and economic uncertainty. Government has also failed in meeting its responsibility to work with industry to develop an acceptable system for commercial waste disposal, which has further hampered nuclear power development.

To correct present government deficiencies and to enable nuclear power to make its essential contribution to our future energy needs, I am announcing today a series of policy initiatives:

(1) I am directing the Secretary of Energy to give immediate priority attention to recommending improvements in the nuclear regulatory and licensing process. I anticipate that the Chairman of the Nuclear Regulatory Commission will take steps to facilitate the licensing of plants under construction and those awaiting licenses. Consistent with public health and safety, we must remove unnecessary obstacles to deployment of the current generation of nuclear power reactors. The time involved to proceed from the planning stage to an operating license for new nuclear powerplants has more than doubled since the mid-1970's and is presently some 10-14 years. This process must be streamlined, with the objective of shortening the time involved to 6-8 years, as is typical in some other countries.

(2) I am directing that government agencies proceed with the demonstration of breeder reactor technology, including completion of the Clinch River Breeder Reactor. This is essential to ensure our preparedness for longer-term nuclear power needs.

(3) I am lifting the indefinite ban which previous administrations placed on commercial reprocessing activities in the United States. In addition, we will pursue consistent, long-term policies concerning reprocessing of spent fuel from nuclear power reactors and eliminate regulatory impediments to commercial interest in this technology, while ensuring adequate safeguards. It is important that the private sector take the lead in developing commercial reprocessing services. Thus I am also requesting the Director of the Office of Science and Technology Policy, working with the Secretary of Energy, to undertake a study of the feasibility of obtaining economical

plutonium supplies for the Department of Energy by means of a competitive procurement. By encouraging private firms to supply fuel for the breeder program at a cost that does not exceed that of government-produced plutonium, we may be able to provide a stable market for private sector reprocessing and simultaneously reduce the funding needs of the U.S. breeder demonstration program.

(4) I am instructing the Secretary of Energy, working closely with industry and State governments, to proceed swiftly toward deployment of means of storing and disposing of commercial, high-level radioactive waste. We must take steps now to accomplish this objective and demonstrate to the public that problems associated with management of nuclear waste can be resolved.

(5) I recognize that some of the problems besetting the nuclear option are of a deep-seated nature and may not be quickly resolved. Therefore, I am directing the Secretary of Energy and the Director of the Office of Science and Technology Policy to meet with representatives from the universities, private industry, and the utilities, and requesting them to report to me on the obstacles which stand in the way of increased use of nuclear energy and the steps needed to overcome them in order to assure the continued availability of nuclear power to meet America's future energy needs, not later than September 30, 1982.

Eliminating the regulatory problems that have burdened nuclear power will be of little use if the utility sector cannot raise the capital necessary to fund construction of new generating facilities. We have already taken significant steps to improve the climate for capital formation with the passage of my program for economic recovery. The tax bill contains substantial incentives designed to attract new capital into industry. Safe commercial nuclear power can help meet America's future energy needs. The policies and actions that I am announcing today will permit a revitalization of the U.S. industry's efforts to develop nuclear power. In this way, native American genius, not arbitrary Federal policy, will be free to provide for our energy future.

Exhibit E-1

Remarks by President Reagan on Nuclear Energy Policy

Part F: AFTER REAGAN'S DECISION

Based on Reagan's support of reprocessing, it would seem that AGNS would surge forth toward completion of BNFP. This was not the case. Dr. Buckham explains why:

"We never believed that Carter's decision was forever — it just didn't make sense. We kept the option of completion open during the entire Carter Administration, but the ramifications of his decision — delays in licensing approval for mixed-oxide fuel, Westinghouse cancellation of the fuel fabrication plant, and Clinch River Breeder Reactor debates — and the delays it caused removed our incentives to risk additional investment. Even so, we were very encouraged by Reagan's decision, but then nothing happened. Bechtel and Westinghouse expressed interest in Barnwell, but wanted a government policy guarantee which was slow in coming. I did not become discouraged until they dropped out in April, 1983. I am still looking for investors because I believe reprocessing will be done. It is just a question of time. As a chemist, I see generating electricity from fossil fuels as such a waste of resources needed in other important areas. Uranium and plutonium have virtually no other possible uses, and reprocessing provides a means to guarantee energy well into the future."

Funding for the R&D efforts expired July 31, 1983, AGNS funds started in May, the same month the lay-offs began. Dr. Buckham had earlier predicted that he could have the plant operational within three years from official go-ahead. He also felt that if he could hold on to his employees until a more sympathetic president took office, Barnwell might be saved. It does not appear as though that will happen. Funding from the nuclear utilities does not look promising as they have no incentive to invest in reprocessing as long as uranium supplies are guaranteed and they are prohibited from using mixed-oxide fuel in the reactors.

In March, 1983, AGNS filed suit against the Federal Government for taking property without just compensation, stating that the 1977 deferral eliminated the opportunity to operate the plant and destroyed the value of their investment. If AGNS wins the lawsuit, the U. S. Government will own BNFP. Dr. Buckham said that he had heard rumors that the government might file an injunction preventing him from selling any plant equipment, but he has not yet received any notice of this.

Part G: THE MCCORMACK PROPOSAL

In 1977 when Carter made his nuclear policy statement, Mike McCormack was the Chairman of the House Science and Technology Subcommittee on Energy Research and Production. Congressman McCormack saw three objectives of his Subcommittee: 1) relieve U. S. dependence on oil, 2) ensure long-term energy supplies, and 3) protect the environment. In meeting these objectives, the subcommittee supported solar, geothermal, fusion, and nuclear fuel cycle projects, and was instrumental in funding R&D activities at BNFP.

In 1983, Mike McCormack is no longer a Congressman, but a consultant in science, energy, and government. Educated in chemistry, he has the background necessary to tie these areas together. His proposal for a Federal Nuclear Fuel Cycle Corporation is presented as Exhibit G-1. In it is an alternative for future use of BNFP.

MC CORMACK ASSOCIATES, INC.*Consultants in Science, Energy and Government*

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WASHINGTON, D.C. 20003

MIKE McCORMACK
President

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2 Feb 83

A Federal Nuclear Fuel Cycle Corporation

The Administration has indicated a reluctance to use budgeted funds to continue development of a nuclear fuel cycle program. On the other hand, industry has indicated that it has very little interest in going ahead on its own, especially without substantial federal involvement and some guarantee of continuity. This would be unacceptable to the Congress.

Serious consideration of a public corporation (a Federal Nuclear Fuel Cycle Corporation) may be in order at this time for handling most of the nuclear fuel cycle. The exact structure of such a corporation may be defined at a later date.

The Federal Nuclear Fuel Cycle Corporation (FNFCC) would handle almost all of the nuclear power fuel cycle in the same way that the federal government handles the fuel cycle for the weapons program. Except for the mining and milling of uranium, and the fabrication of uranium (only) fuel elements, the federal government would pre-empt ownership of all facilities used in the fuel cycle and operate them by contract with private industry (as with the weapons fuel cycle). Ownership of all fissile and fertile

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material would be pre-empted by the government, starting after milling. The FNFCC would lease fuel elements to any utility, foreign or domestic (with IAEA supervision for foreign utilities) on condition that the fuel elements are returned for reprocessing. The United States will probably need three fuel cycle centers: one at Barnwell (which could be purchased by the FNFCC), one at Hanford, and one at some site in the South or Mid-west. Each site would include a reprocessing plant built to produce a stream of blended uranium and plutonium, and a stream of waste for immediate glassification. The uranium-plutonium blend would be in such ratios as would be used for fuel, but would not work in any weapon.

The FNFCC would probably be controlled by a Board of Directors nominated by the President and confirmed by the Senate. Initial financing could come from assessments against utilities for reprocessing of existing spent fuel.

Back-of-the-envelope calculations indicate that with a charge of perhaps 3 mils per kilowatt hour of nuclear electricity produced, all of the operations of the corporation, all of its debts, and the nuclear power research, development, and demonstration presently funded as part of the DOE budget could be funded. This would include the CRBR.

(The revenue from one conventional (1000 MWe) power plant, operating at 67% load factor, is \$6 million/yr for each one mil/KWH.

page 3.

By 1985, there will be about 80 GWe of nuclear power on the line in the United States. At 3 mils/KWH, these plants would produce about \$1.5 billion/yr for FNFCC operations.)

An FNFCC could absorb Barnwell and the CRBR, along with all enrichment facilities. Thus, all these items would be removed from the budget.

Private industry would perform all operations on cost-plus "Go Cos", thus eliminating any potential to cut corners on safety to make a profit.

Small nations with a few nuclear power plants would find it cheaper to lease fuel from the FNFCC than to try to reprocess it themselves. This would constitute a major -- and realistic -- non-proliferation initiative.

Part H: REPROCESSING IN OTHER MAJOR NUCLEAR POWER COUNTRIES

Reprocessing is performed by several countries at present, and additional plants are in the planning or construction phase. France and the United Kingdom are the world leaders in this field, both contracting out to other countries for fuel reprocessing services. The French reprocessing corporation, COGEMA, has contracts with thirty different utilities in six different countries operating some seventy power reactors. These six countries are Japan, West Germany, Switzerland, Belgium, the Netherlands, and Sweden. British Nuclear Fuels Limited presently reprocesses Swedish, Spanish, and Japanese spent fuel, and with the Thermal Oxide Reprocessing Plant (THORP) facility now being constructed, they will have facilities to reprocess light-water reactor fuel and expect to have additional contracts after completion. Japan and West Germany are in the process of building large scale reprocessing plants to handle at least a portion of their domestically produced spent fuel. One very basic reason for these countries to reprocess is the lack of or a small domestic supply of uranium, unlike the United States and Canada who presently do not reprocess spent fuel. However, not all uranium used for reactor fuel in the U. S. is from domestic sources.

In France, the Marcoule plant began reprocessing for the military in 1958 and now reprocesses spent metallic fuel from the early gas-cooled reactors. A second plant, La Hague, began operating in 1967. By 1976, additions to this plant enabled it to handle oxide fuel from the light-water reactors, and in 1979, modifications were made to handle breeder fuel. Enlargements and a new facility are planned. Both Marcoule and La Hague utilize the Purex process.

The British modified and expanded its military reprocessing plant at Windscale to handle spent power reactor fuel by 1957. The second generation plant used the Purex process and was operational in the early 1960's. These facilities reprocessed the magnox fuel used in the British reactors which does not store easily in water because of the susceptibility of the cladding to corrosion causing radioactivity buildup in the storage pools. The newest Windscale facility, THORP, will provide the capacity to handle oxide spent fuel which is used in their advanced gas-cooled reactors. The contracts with other countries can be more easily fulfilled with this increased capacity.

The Japanese built a research facility, Tokimura, and are building a larger plant to reprocess their spent fuel. In their contract with the United States for uranium fuel, they were obliged to obtain permission to reprocess. This permission was obtained during the Carter Administration.

West Germany built a research facility at Karlsruhe which utilized the Purex process. A larger plant is being constructed by DWK, the company established by the utilities. Reprocessing is considered an essential part of the Federal

Republic of Germany's plan for closing the nuclear fuel cycle and is part of their overall energy plan of increasing reliance on nuclear power.

Other countries who have or have had research plants in operation include Italy, Argentina, Spain, Yugoslavia, Russia, China (military), India, and Canada.

Part I: DEPARTMENT OF ENERGY'S POSITION

In a speech at the Institute of Nuclear Materials Management 24th Annual Meeting (7/10-13/83), Kermit Laughon, Director of the Office of Spent Fuel Management and Reprocessing Systems, U. S. Department of Energy, gave the present conditions as follows:

" Commercial reprocessing of spent nuclear fuels will occur in the United States when the economics are shown to be favorable, regulatory uncertainties are resolved, and when our Government and industry find a mutually supportive arrangement for proceeding. . . . The more immediate issue is whether or not the nuclear industry will step forward to help preserve the option of reprocessing at the Barnwell Nuclear Fuel Plant in Barnwell, South Carolina. . . . Since 1977, it has become clear that other countries intend to proceed with reprocessing regardless of its fate in the United States, indicating that the unilateral U. S. prohibition of domestic reprocessing did little to alter the nuclear power strategies of other countries. . . . it remains clear that as our installed nuclear power capacity increases, better uranium utilization, through breeder reactors and possibly mixed-oxide recycle in light-water reactors, will require reprocessing. Since the lead time for establishing a mature reprocessing industry is one or more decades, there are national incentives for moving forward with some reprocessing efforts in the near term to provide a technical and economic basis for use in longer term planning by both Government and industry.

If the United States is to have commercial reprocessing in the next 10 years there is only one practical opportunity, the Barnwell Nuclear Fuel Plant. In considering reprocessing efforts that might be undertaken in the next decade, the discussion inevitably centers on this plant. Further, if a way to complete and operate this partially constructed plant cannot be found, a totally new venture between now and the end of this century would seem to be out of the question. Therefore, it is clear that if we are to move forward in the next decade there must be industry support for the Barnwell plant as well as tangible Government support.

Anyone who believes in the merits of civilian nuclear power and understands the technology will agree that reprocessing should be an integral step in the nuclear fuel cycle. The question now appears to be whether or not industry will have sufficient incentives to provide the minimal funding needed to preserve Barnwell in its present condition as an option for future reprocessing. The next few months will provide an interesting test for the nuclear industry in this regard."

INSTRUCTORS NOTES

This case study presents an example of one company's struggle with government policy shifts in a highly regulated industry. The company invested a considerable amount of time and money in what was expected to be a profitable business that they believed would provide an important service in answering the nation's energy needs. Close to completion of the company's facilities, the government reversed policy preventing the company from recovering any of its investment. Recently, the policy was reversed again, but the company still felt there were too many uncertainties to proceed.

This study illustrates one very important aspect of our government — the ability to change policy when deemed necessary. Even though this is desirable in a Democracy, there can be instances where this conflicts with the free enterprise system of Capitalism. It also points out the risk involved in capital ventures as well as the hesitancy of the government to take over an industry that has not proven profitable.

This study provides chemical, mechanical, and nuclear engineering students with examples of problems they may be faced with in their careers. The energy needs of our nation and the world must be met. Some choices have to be made that will not satisfy every need or desire. The available choices may all have drawbacks, whether social, environmental, economic, or technical. Choices made today will affect all the generations to follow because most energy comes from finite resources. Reprocessing provides a means to stretch one of the resources into fuel for many years to come.

The following provides suggestions for questions, assignments, or discussion involving this case study.

Part A: THE NUCLEAR FUEL CYCLE

1. Presently, there are two methods being used for disposal of high-level wastes: 1) Canada stores spent fuel in dry storage areas, 2) reprocessing wastes are vitrified in France and the United Kingdom. Under the Nuclear Waste Policy Act of 1982, research into methods and locations for disposal will be performed. Have the students compare the differences in the type and amount of wastes and discuss the results. Appendix 1 gives some information relative to toxicity.
2. Chemical engineering students might be required to write the chemical equations for the processes and discuss why and how this separation occurs.

Part B: FROM GOVERNMENT TO PRIVATE INDUSTRY

1. Engineering students might be required to go back to the original design of military reprocessing plants and then review the design of the commercial reprocessing plants and compare the differences. What differences exist between military reprocessing and spent fuel reprocessing based on the length of time the fuel stays in a nuclear reactor?

Part C: THE CARTER ADMINISTRATION

1. Is plutonium found in nature?
2. What material can be used to make nuclear weapons?
3. Is plutonium dangerous to hold in your hand? Why? Which isotopes?
4. What is a medical use of Plutonium 238?
ANSWER: Power source for heart pacemakers.
5. Is plutonium in small amounts lethal?
6. What is required for plutonium to begin a chain reaction?
7. How does a breeder reactor produce fuel?
8. What was Carter's biggest concern in reprocessing? Could he have chosen a different means of controlling the spread of technology in this area to other countries? How might he have done this and retain reprocessing in the U. S?
9. If you were asked to design a shipping rig for a tractor-trailer truck to transport spent fuel assemblies, what safeguard features would you incorporate to prevent sabotage during transport? What other factors must be considered?

Part D: THE DOE CONTRACT

1. For nuclear engineering students: How would mixed-oxide fuel be different from uranium fuel in a light-water reactor?
2. Can you think of other technical (chemical or physical) means to prevent diversion of plutonium at a reprocessing plant other than the Advanced Integrated Safeguards System described in this section?

Part E: THE REAGAN ADMINISTRATION

1. What areas are cited as problems for the nuclear power industry that the government has created?
2. In Reagan's statement, items (2), (3), and (4) are all related. Discuss their relationship and the role of reprocessing in future energy projections.

Part F: AFTER REAGAN'S DECISION

1. If you were president of AGNS, what would you have chosen to do? Why? Make a list of each point you considered in coming to this conclusion.
2. What incentives are there for government ownership of BNFP on the part of 1) the government, 2) the industry, 3) society?

Part G: THE MCCORMACK PROPOSAL

1. How could this proposal meet the nonproliferation requirements of the U.S?
2. Why would such a proposal even be considered in a capitalist country?
3. What are examples of other industries owned by the government? What makes this acceptable in some cases?

Part H: REPROCESSING IN OTHER MAJOR NUCLEAR POWER COUNTRIES

1. Before reading this section, list a few reasons why reprocessing would be attractive to some countries.
2. Compare "Socialism" and "Democracy." Discuss how the nuclear industry has evolved under both types of government. Why is it easier to do long-term planning in a Socialist government?
3. Have the students research the French breeder reactor program and find out how much fuel has been "produced." Does it work? How?

Part I: DEPARTMENT OF ENERGY'S POSITION

1. Have the students discuss what they think DOE will do when the BNFP closes its doors. Will they take it? Find out what actually happens(happened) to BNFP and AGNS.

THE TOXICITY OF NUCLEAR WASTES

The primary function of a Federal waste repository will be to prevent release of radioactivity into the biosphere. The purpose of placing wastes in geologically stable formations is to protect the environment from the toxicity of components which have extremely long half-lives. In comparing the alternatives of spent fuel disposal and reprocessing, it is consequently of interest to compare toxicity of reprocessing wastes with that of fuel assemblies.

Toxicity can be expressed in terms of the volume of water which would be required to dilute the total curie content of the "waste" generated from one metric ton of spent fuel to drinking water, based on current standards and assuming theoretical solubility of all components. When the total radioactivity levels of reprocessing wastes and spent fuel elements are compared as a function of decay time, the results show that for the first few hundred years, the hazards associated with either spent fuel or high-level waste from reprocessing are in the same range. This is due to the presence of fission products, which account for the greatest hazard during this time frame. However, after a few hundred years, the hazards of spent fuel remain higher than reprocessing waste because of the presence of long-lived actinides. Comparing both with the hazards associated with the original ore body, the results show that for the waste to reach a hazard value equivalent to that of the original ore the time intervals are (1) 500 years for high-level waste from reprocessing, and (2) 10,000 years for spent fuel.

From this it may be concluded that:

- a. The difference between reprocessing waste and spent fuel elements is one of degree, not of kind.
- b. The time-integrated activity for reprocessing waste is less than that for spent fuel elements by a factor of about three. This is true even if some of the reprocessing waste were to come from mixed-oxide fuel.
- c. No matter what criterion is chosen as the threshold toxicity, it takes longer for spent fuel elements to become innocuous than it does for reprocessing waste.

From: Barnwell Nuclear Fuel Plant Journal; Background Material, Summaries, and General Information on BNFP Programs and Nuclear Fuel Reprocessing; February, 1980; prepared by Allied-General Nuclear Services.